

# MEMBRANE SEPARATION

# What is Membrane separation ?

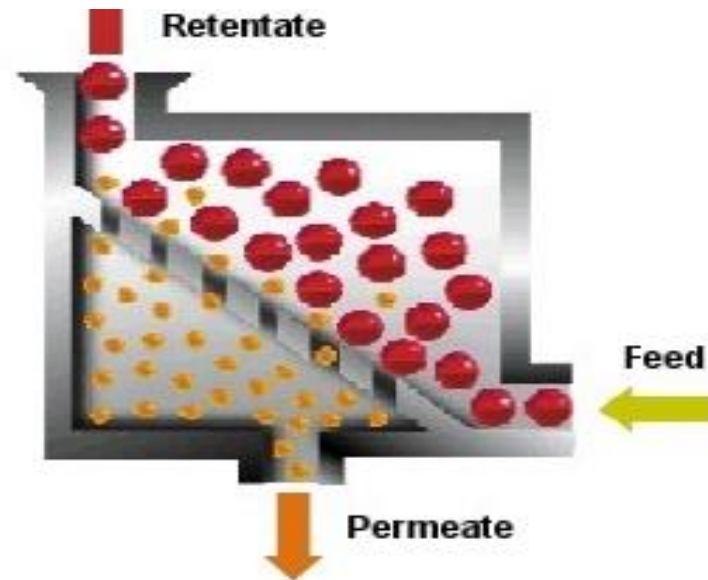
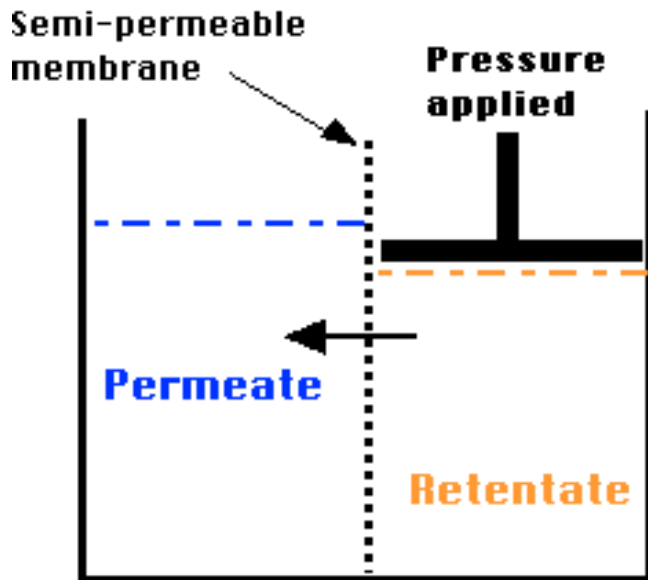
It is a process of separating food components by using semi-permeable membranes, basing on the molecular size & molecular weight of the components.

The driving forces of the separation process are, for example, differences in concentration or pressure between the two sides of the membrane.

Membrane separation processes remove much smaller substances, such as viruses and dissolved ions, from the water.

# Principle of operation

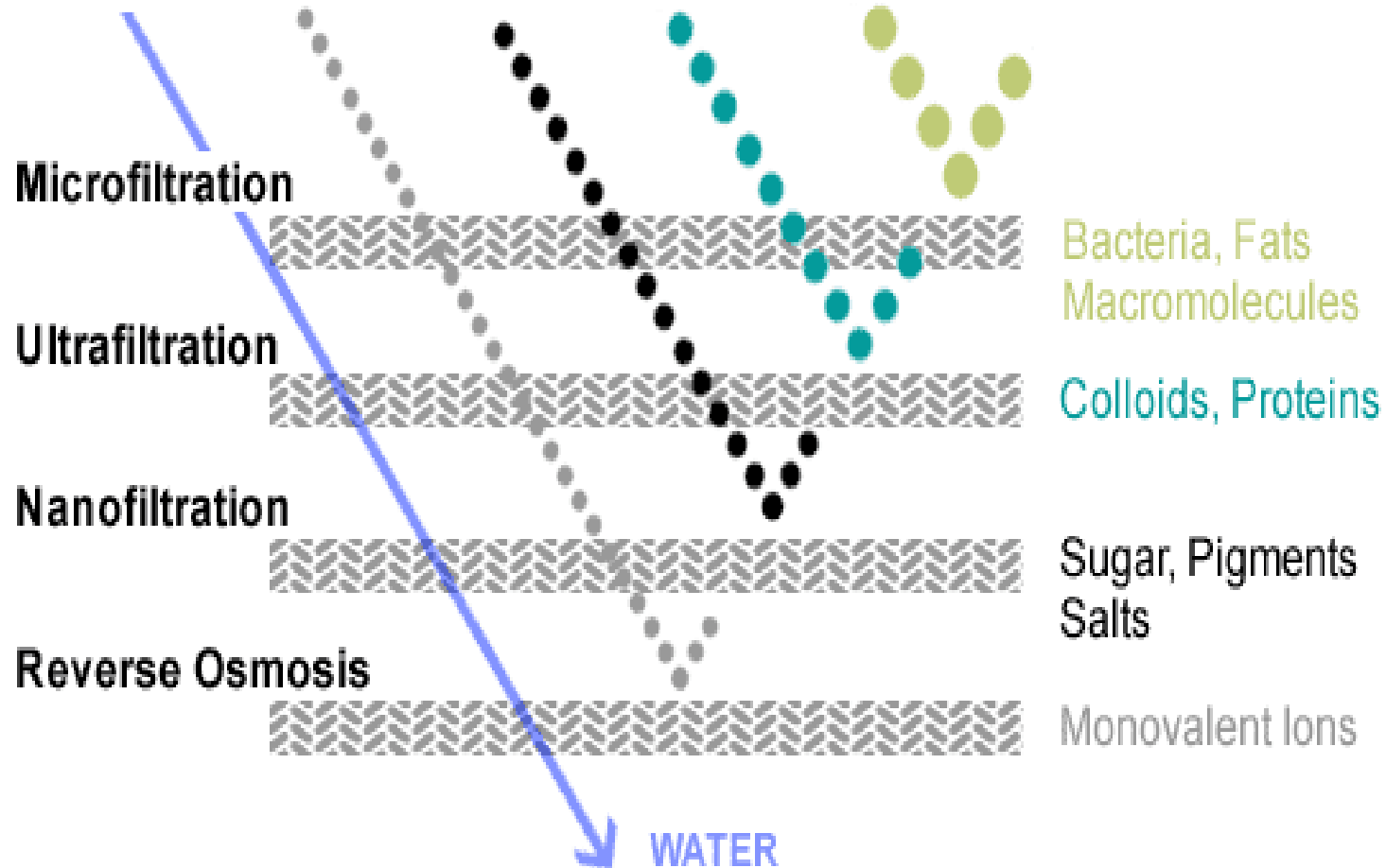
## Membrane Processing



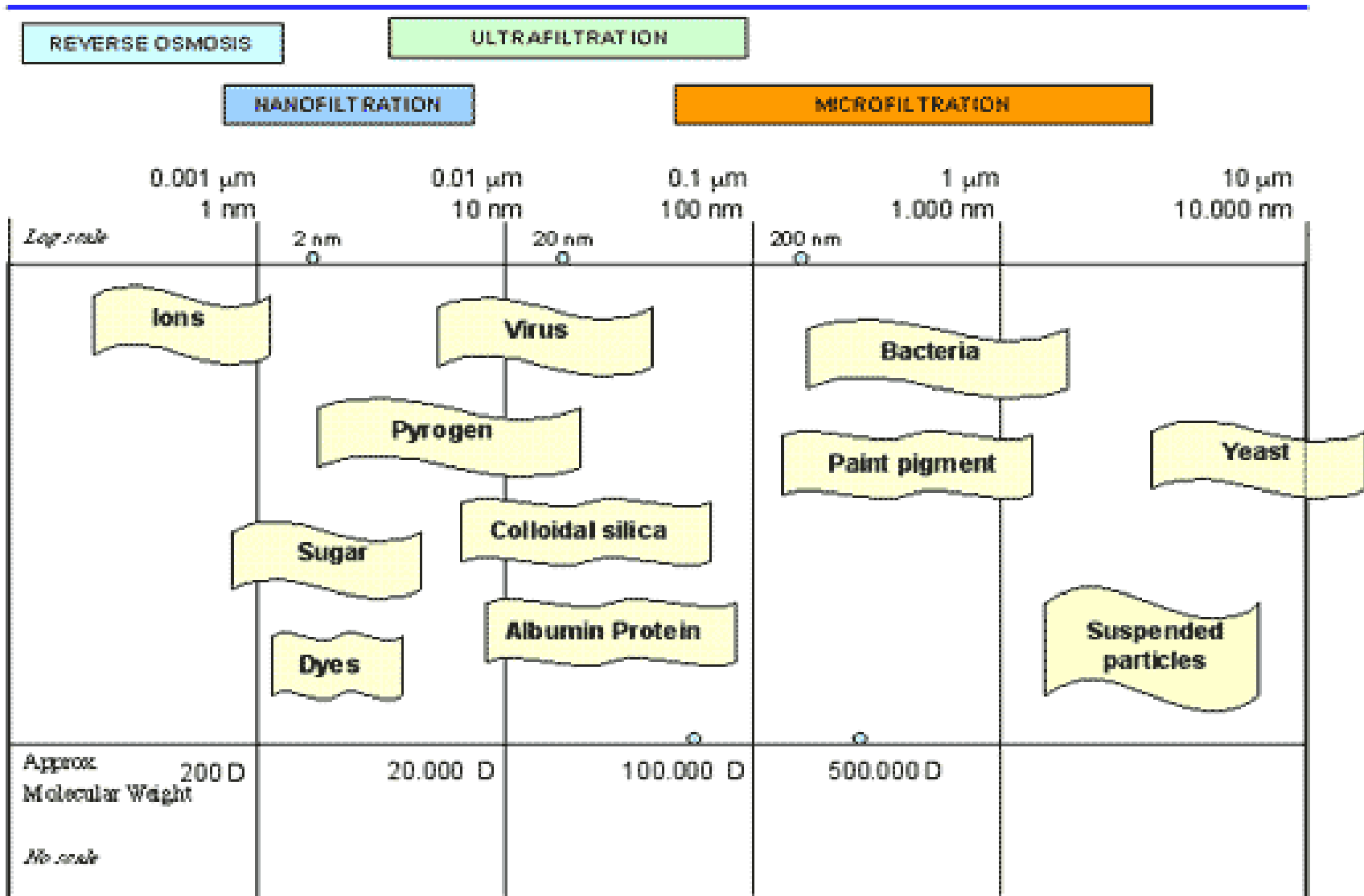
# Membrane processing Technologies

- Reverse osmosis
- Nano filtration
- Ultra Filtration
- Microfiltration
- Pervaporation
- Ion exchange
- Electro dialysis

# Different Membrane concentrations



# Range of Concentration in various filtration systems



## **Reverse osmosis (RO)**

**Concentration** of solution by removal of water

## **Nanofiltration (NF)**

Concentration of organic components by removal of part of monovalent ions like sodium and chlorine (partial **demineralisation**).

## **Ultra filtration (UF)**

Concentration of large and macro molecules

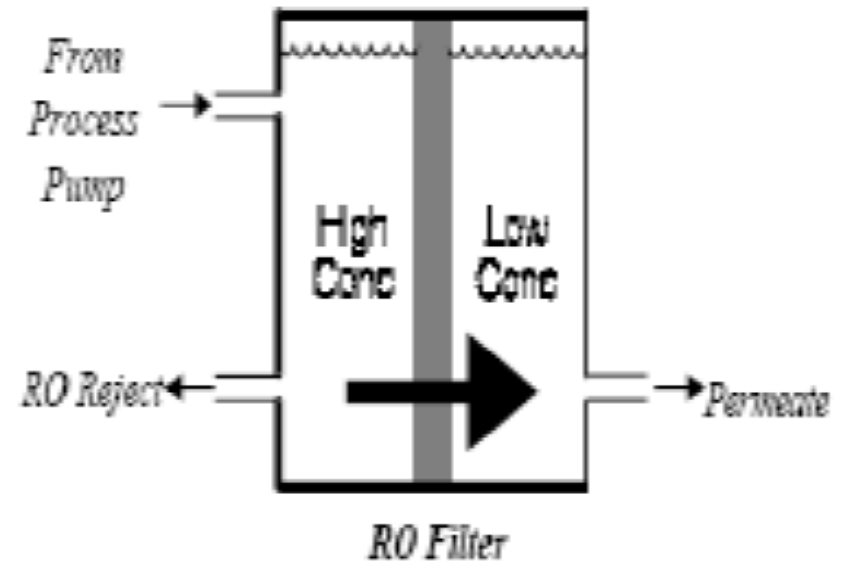
## **Microfiltration (MF)**

**Removal of bacteria**, separation of macromolecules

## Reverse osmosis....

A membrane separation process, driven by a pressure gradient, in which the membrane separates the solvent (generally water) from other components of a solution.

Solvent flow is opposite to the normal osmotic flow.



The membrane pore size is very small allowing only small amounts of very low molecular weight solutes to pass through the membranes.



## Reverse osmosis...APPLICATIONS

Broadly used to separate water from **low molecular weight solutes (salts, aroma compounds etc.)**, which have high osmotic pressure.

- Concentrate & purify fruit juices, enzymes, fermentation liquors & vegetable oils; Pre-concentrate juices & dairy products before evaporation.
- Concentrate wheat starch, citric acid, egg white, milk, coffee, syrup, natural extracts & flavors.
- To clarify wine & beer (De-alcoholisation for low alcohol wines & beers)
- To determine & purify water from boreholes or rivers or desalination of sea water.
- Water & waste water purification.
- Concentration of whey during cheese manufacture.

# RO Materials & Equipments

- Polymer having high permeability for water, high rejection for soluble salts and durability.
- Cellulose acetate is outstanding being inexpensive
- Polyacrylo-nitrile, polyamides, polyurethans are also used, but they have low temperature resistance and low pH range.
- Polysulphones and ceramic materials can withstand high temperature and wider pH range.
- **Operating pressure ranging from 40 to 80 bar @ 450 to 2400 lit/h of flux.**

# Advantages of Reverse osmosis

- Very economical
- Low operating cost
- Ability to avoid heat treatment process

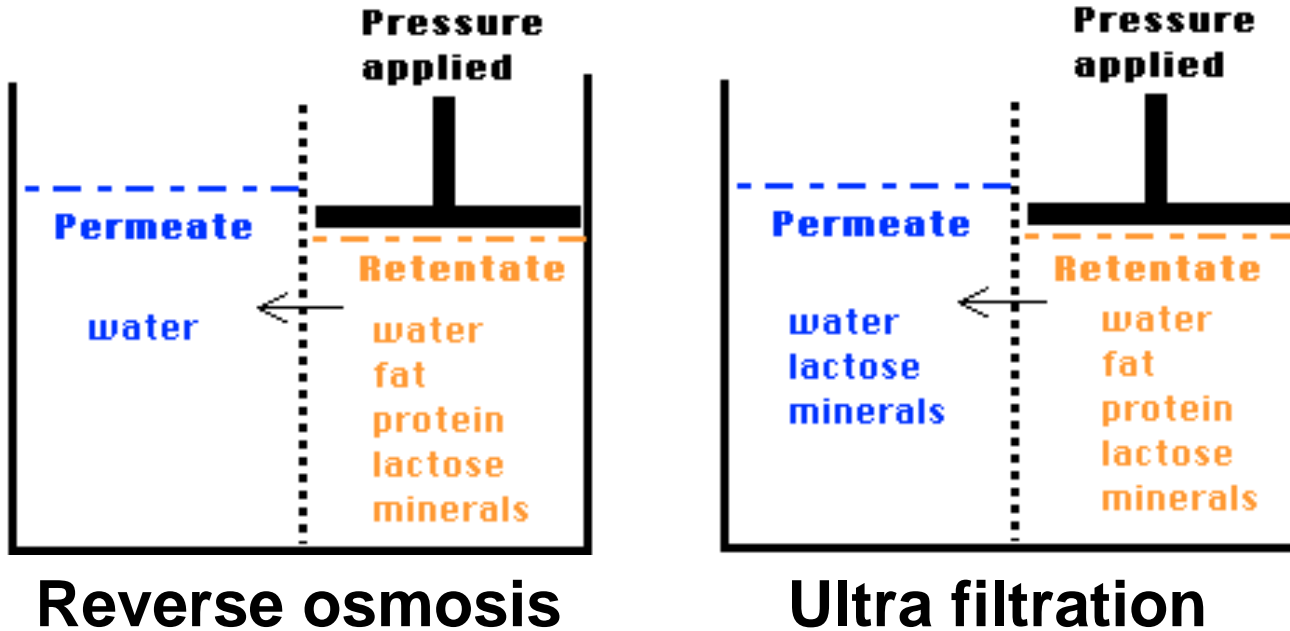
# Nano filtration (NF)

- New class of pressure-driven membrane processes that lies between RO and UF
- Pressure range: 10-50 bar (lower pressure than RO)
- Rejects ions with more than one negative charge (such as  $\text{SO}_4^{2-}$ ,  $\text{CO}_3^{2-}$ )
- Also known as loose reverse osmosis
- Removes materials having molecular weight between 300 to 1000 Da.
- Employed for pre concentration for R.O.

# Nano filtration

- Removal of inorganic salts  
Na, K, Cl, urea, lactic acid,
- Partial demineralization
- Membranes that leak particle species with a radius in the nanometer range
- Reduce salty taste
- Pretreatment for electro dialysis, ion exchange
- Acid removal
- Reduce salt from cheese making
- Dispersed particles such as colloids, fat globules etc. are separated.

# Ultra filtration

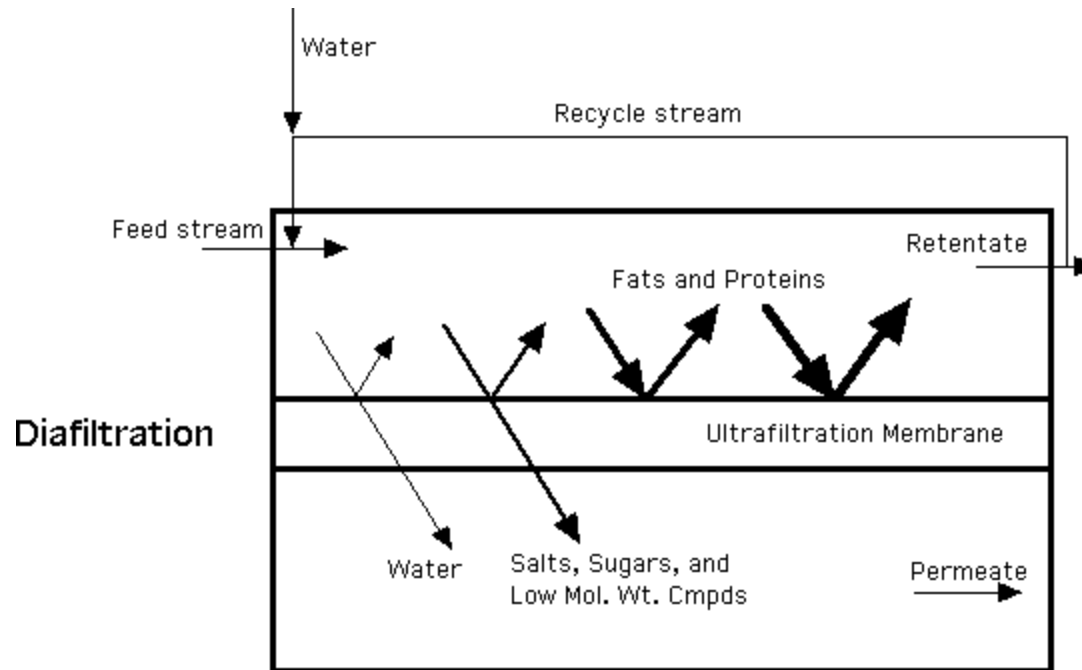


Ultrafiltration is similar to reverse osmosis with low pressure of operation.

In UF, the membrane pore size is larger allowing some components to pass through the pores with the water. It is a separation/ fractionation process.

# Dia-filtration

Dia-filtration is a specialized type of ultra-filtration process in which the retentate is diluted with water and re-ultra filtered, to reduce the concentration of soluble permeate components and increase further the concentration of retained components.



# Equipments

- U.F. membranes have higher porosity.
- They operate under low pressure (0.05 to 10 bar @ 2400 lit/hr of flux).
- Polymers like poly-sulphones, poly-amides, PVC, poly-styrene, poly-carbonates and poly-ethers are normally used.



## Applications of Ultra filtration

- Most commonly used to **pre concentrate milk** prior to preparation of other range of dairy products
- **Concentration of sucrose & tomato paste.**
- **Separation & concentration of enzymes**, other proteins or pectin.
- Treatment of water to remove bacteria and contaminants greater than  $0.003 \mu$  dia.
- **To selectively remove lactose and salts from the whey.**
- Removal of protein hazes from honey & syrups.
- Pretreatment for R.O. to prevent fouling by organic and colloidal material



Integrated Membrane filtration system comprising UF plant for WPC & RO plant for Lactose concentration  
Source : DSS-Internet





**Large membrane filtration installation for whey processing.**

## Microfiltration

- Microfiltration (MF) designates a membrane separation process similar to UF but with even larger membrane pore size allowing particles in the range of 0.2 to 2 micrometers to pass through.
- The pressure used is generally lower than that of UF process.
- MF is used in the dairy industry for making low-heat sterile milk.

# Applications of membrane filtration

		Permeate	Concentrate
RO	dyeing effluent	clean water	BOD, salt, chemicals, waste products
	water	low salinity water	salty water
	whey	low BOD permeate	whey concentrate
NF	antibiotics	salty waste product	desalted, concentrated antibiotics
	dyeing effluent	clean, salty water	BOD/COD, color
	water	softened water	waste product
	whey	salty waste water	desalted whey concentrate
UF	antibiotics	clarified fermentation broth	waste product
	bio-gas waste	clarified liquid for discharge	microbes to be recycled
	carrageenan	waste product	concentrated carrageenan
	enzymes	waste product	high value product
	milk	lactose solution	protein concentrate for cheese production
	oil emulsion	oil free water (<10 ppm)	highly concentrated oil emulsion
	washing effluent	clarified water	dirty water (waste product)
	water	clarified water	waste product
	whey	lactose solution	whey protein concentrate
	xantan	waste product	concentrated xantan

## Advantages and limitations of different membranes used in R.O. and U.F.

Type of membrane	Advantages	Limitations
Cellulose acetate	High permeate flux, good salt rejection, easy to manufacture	Operates below 30 <sup>0</sup> C and pH range 3 to 6. broken down by chlorine
Poly sulphones, poly amides, PVC, poly styrene, poly carbonates, poly ethers	Better temp. resistance Better pH resistance Better chlorine resistance, easy to fabricate	Don't withstand high pressure-restricted to U.F., Poly amides are more sensitive to chlorine than cellulose acetate
Composite or ceramic membranes (porous carbon, zirconium oxide, Alumina)	Inert, very wide range of operating temp. and pH, resistance to chlorine and easily cleaned	Expensive

**Thank You!**